US005983038A

# United States Patent [19]

**Sato et al.**

[11] **Patent Number: 5,983,038**

[45] **Date of Patent: Nov. 9, 1999**

[54] **WHITE BALANCE ADJUSTING DEVICE**

[75] Inventors: **Koichi Sato**; **Tahei Morisawa**; **Yasuhiro Yamamoto**, all of Tokyo, Japan

[73] Assignee: **Asahi Kogaku Kogyo Kabushiki Kaisha**, Tokyo, Japan

[21] Appl. No.: **08/761,903**

[22] Filed: **Dec. 9, 1996**

[30] **Foreign Application Priority Data**

Jan. 23, 1996 [JP] Japan .................................... 8-028496

[51] **Int. Cl.**$^{6}$ .................................................... **G03B 19/00**

[52] **U.S. Cl.** .............................................................. **396/429**

[58] **Field of Search** .............................. 396/30, 429, 225, 396/226; 430/42, 43; 358/515, 516

[56] **References Cited**

U.S. PATENT DOCUMENTS

| | | | |
|---|---|---|---|
| 4,945,423 | 7/1990 | Takanashi et al. | 358/300 |
| 5,132,825 | 7/1992 | Miyadera . | |
| 5,251,021 | 10/1993 | Parulski et al. | 358/500 |
| 5,315,410 | 5/1994 | Takanshi et al. | 358/471 |
| 5,424,156 | 6/1995 | Aoki et al. . | |
| 5,550,587 | 8/1996 | Miyadera . | |
| 5,555,205 | 9/1996 | Okabe | 365/108 |
| 5,568,194 | 10/1996 | Abe . | |
| 5,646,927 | 7/1997 | Shimizu et al. | 369/99 |

FOREIGN PATENT DOCUMENTS

| | | |
|---|---|---|
| 5-2280 | 1/1993 | Japan . |

*Primary Examiner*—Safet Metjahic
*Assistant Examiner*—John Chizmar
*Attorney, Agent, or Firm*—Greenblum & Bernstein P.L.C.

[57] **ABSTRACT**

A white balance adjusting device includes a rotational color filter and a shutter which are provided between a photographing optical system and an electro-developing recording medium having first, second, and third recording areas. Red, green, and blue images are recorded in the first, second, and third recording areas through the rotational color filter. A photometry sensor is provided behind the electro-developing recording medium to sense the intensity of light passing through the first, second, and third recording areas. When the sensed light reaches a proper photometry value, the application of a voltage to the electro-developing recording medium is stopped, and the shutter is closed.

**20 Claims, 12 Drawing Sheets**

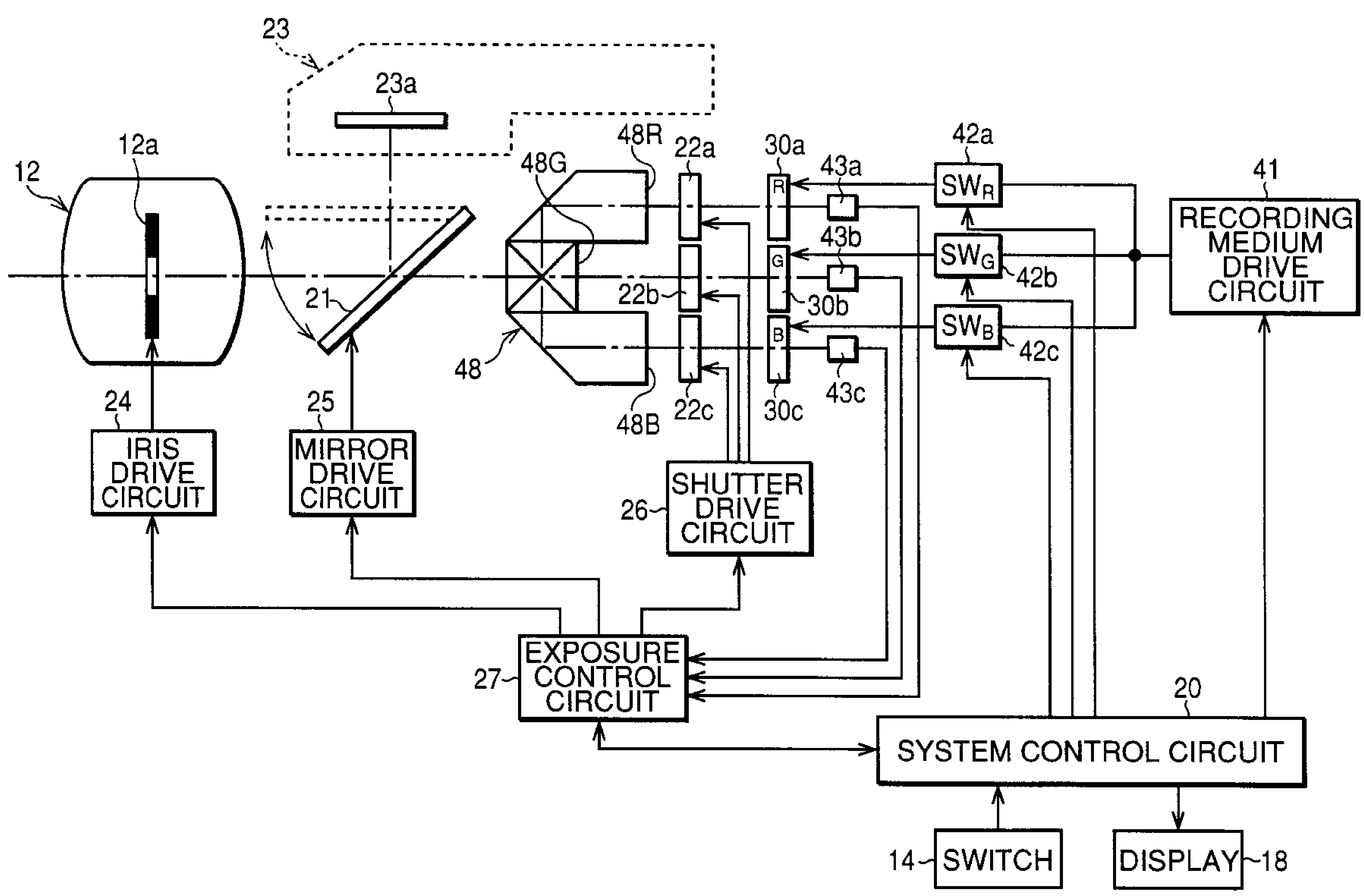


FIG. 1

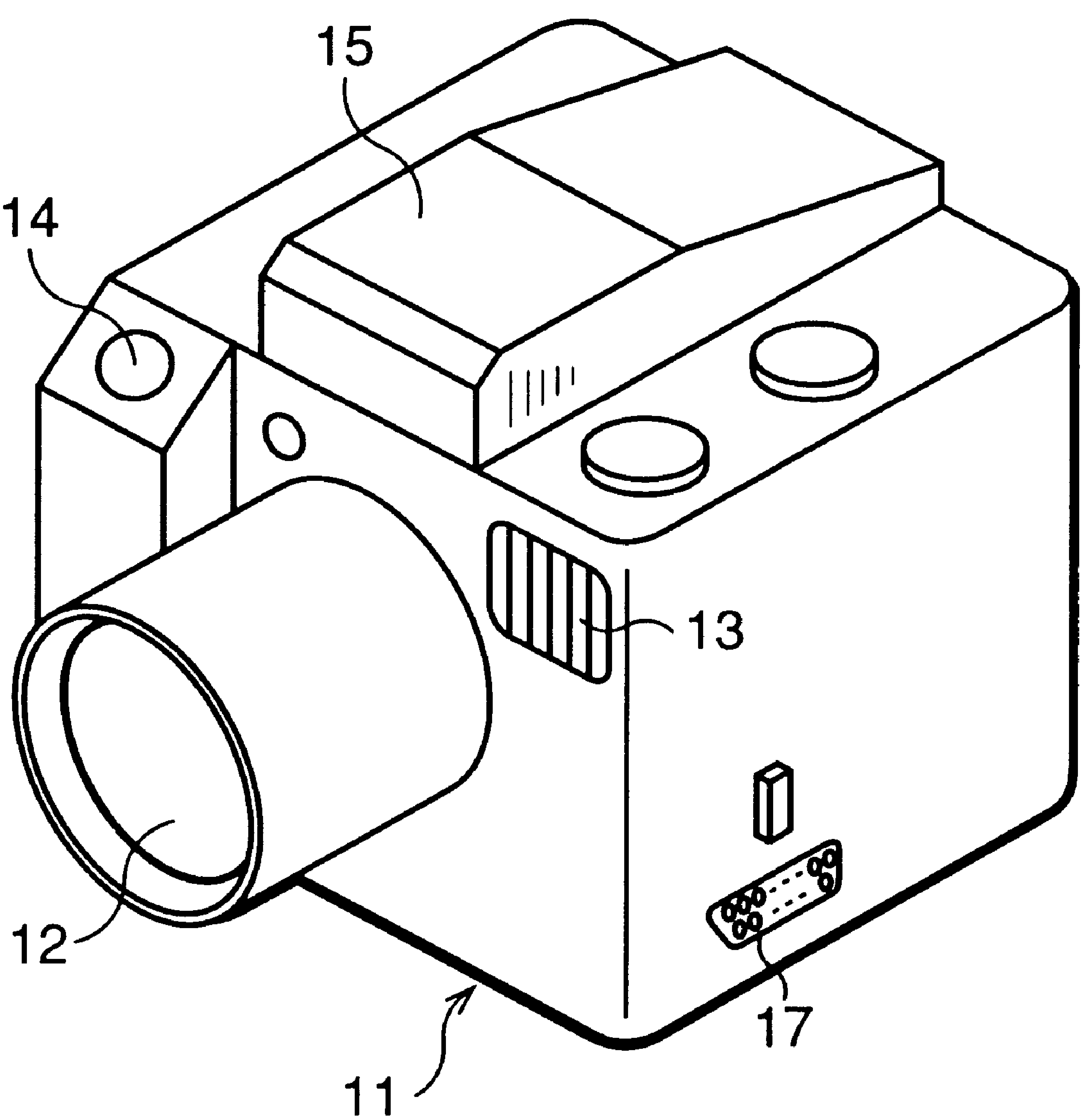


FIG.2

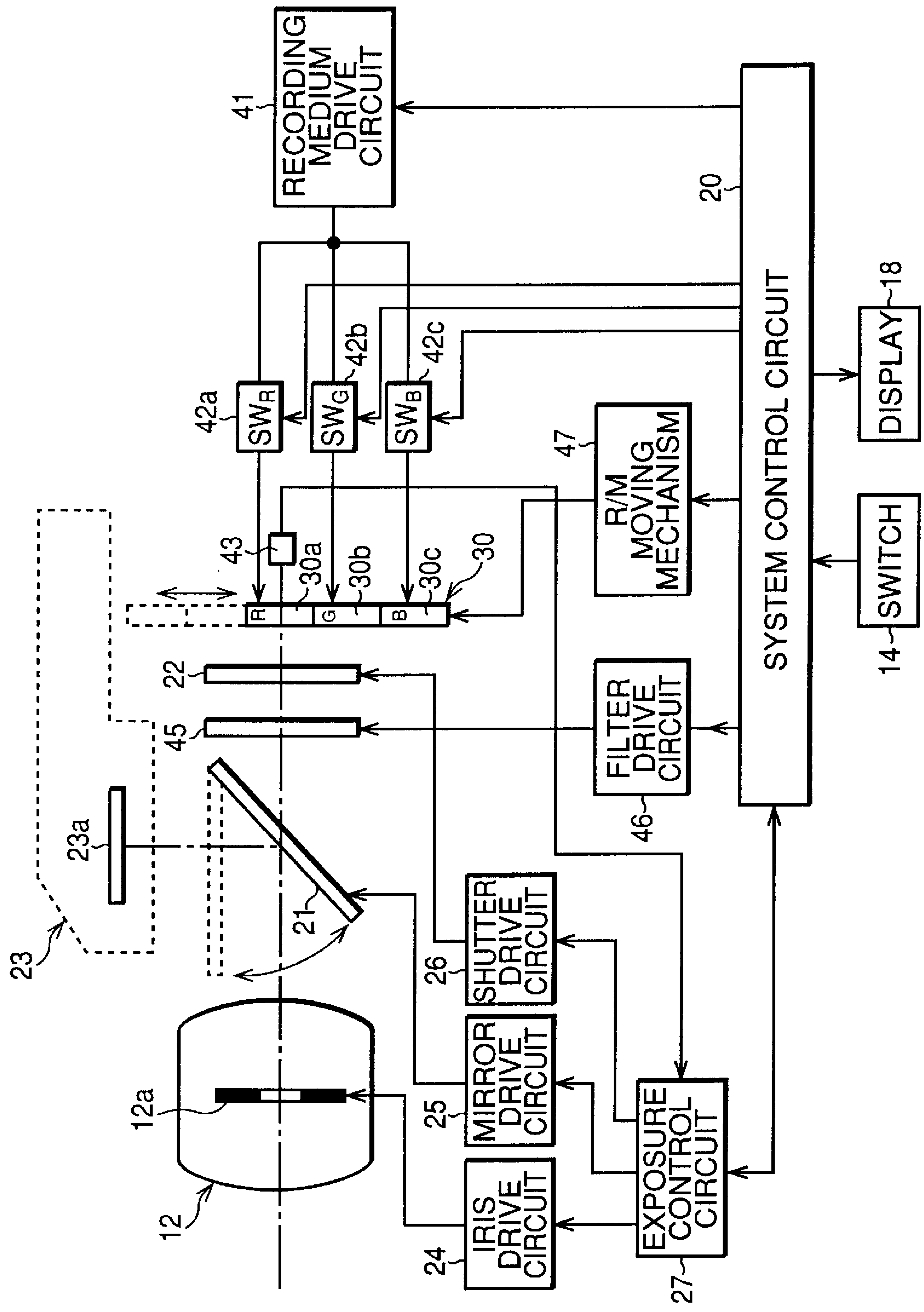

RECORDING MEDIUM DRIVE CIRCUIT
41
20
SYSTEM CONTROL CIRCUIT
DISPLAY
18
SWITCH
14
R/M MOVING MECHANISM
47
FILTER DRIVE CIRCUIT
46
SWR
SWG
SWB
42a
42b
42c
43
30a
30b
30c
30
R
G
B
22
45
23a
23
21
12a
12
SHUTTER DRIVE CIRCUIT
26
MIRROR DRIVE CIRCUIT
25
IRIS DRIVE CIRCUIT
24
EXPOSURE CONTROL CIRCUIT
27

FIG.3

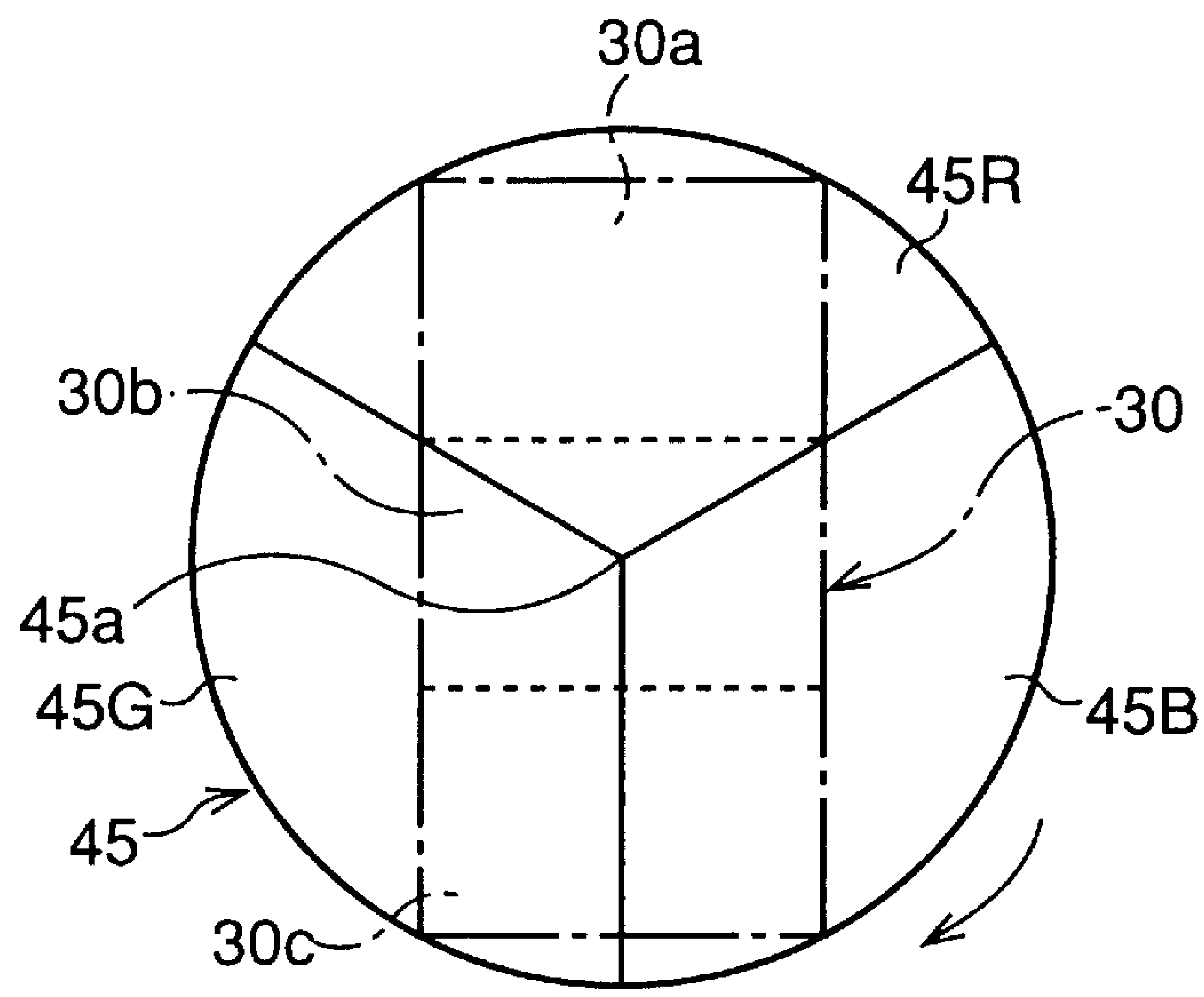



FIG.4

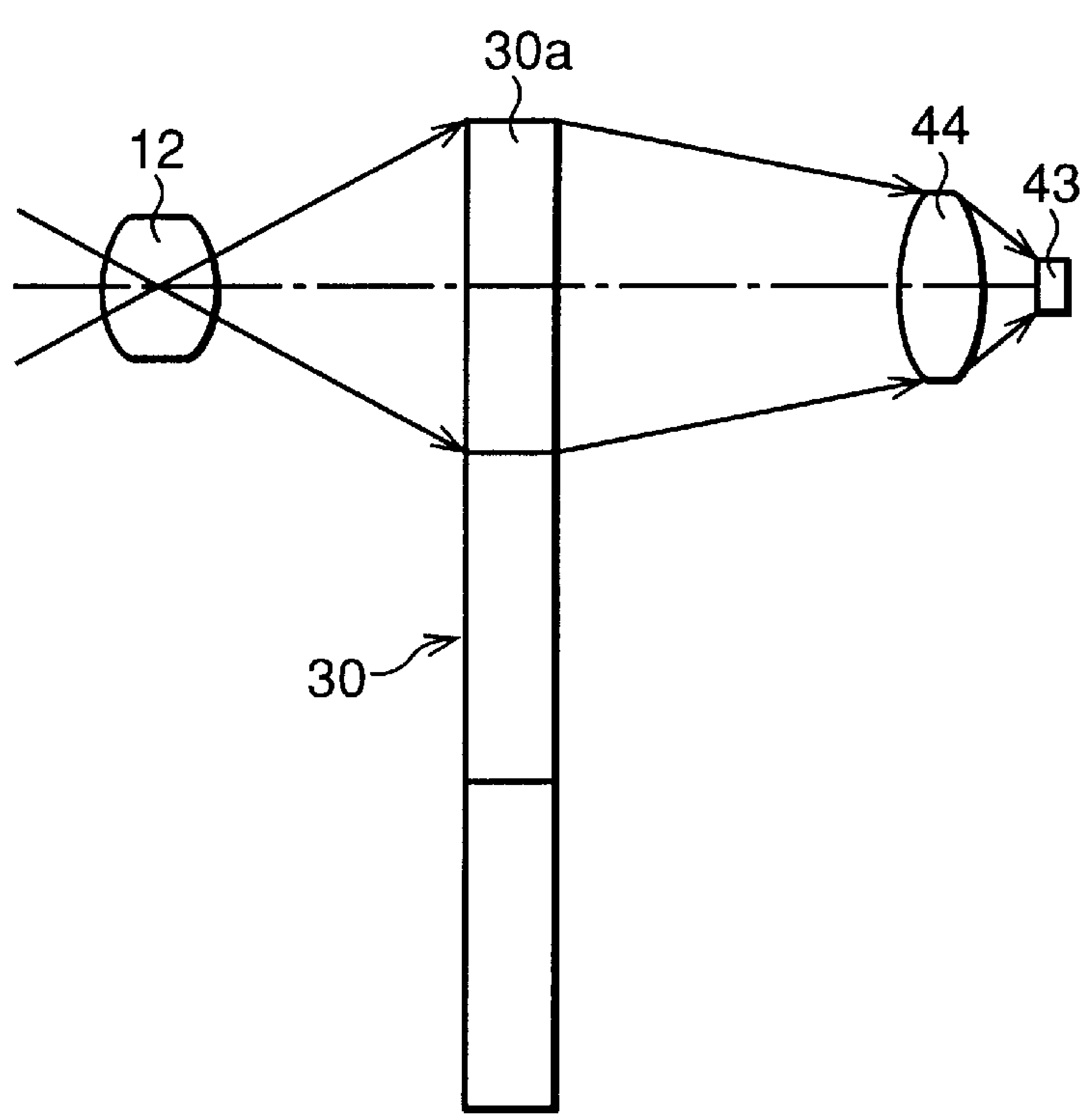


FIG. 5

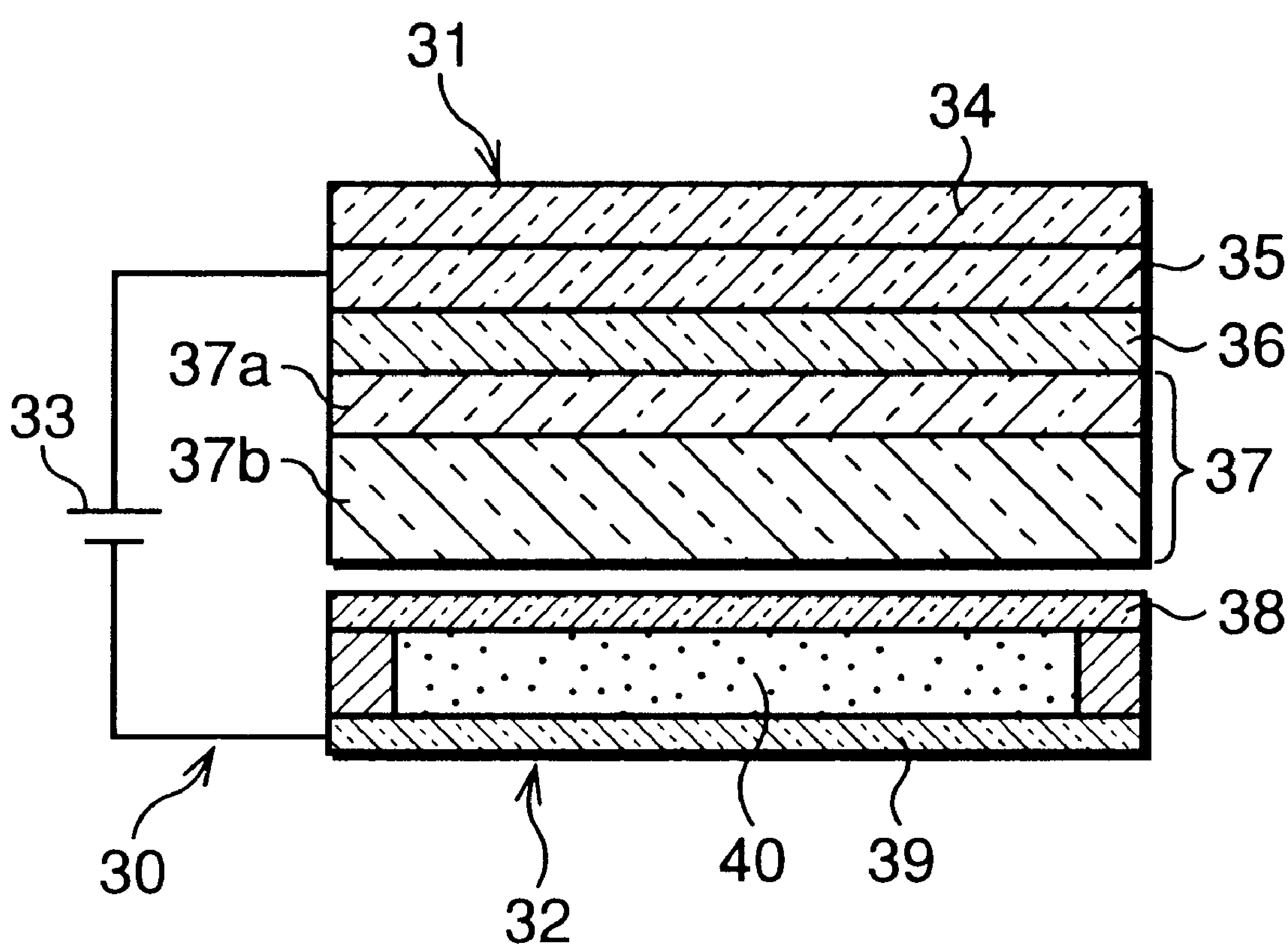


FIG. 6A

FIG. 6B

FIG. 6C

FIG. 6D

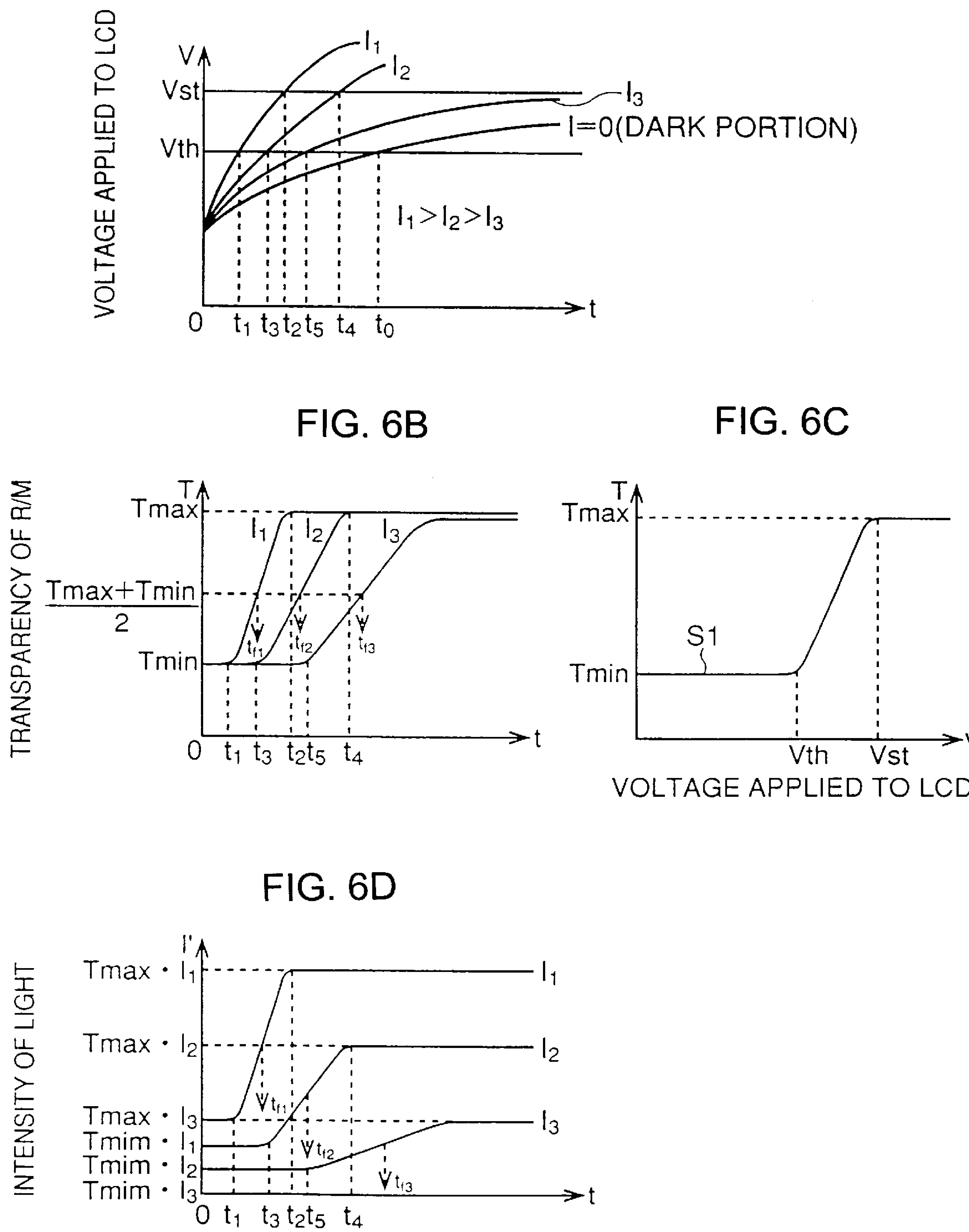


FIG.7

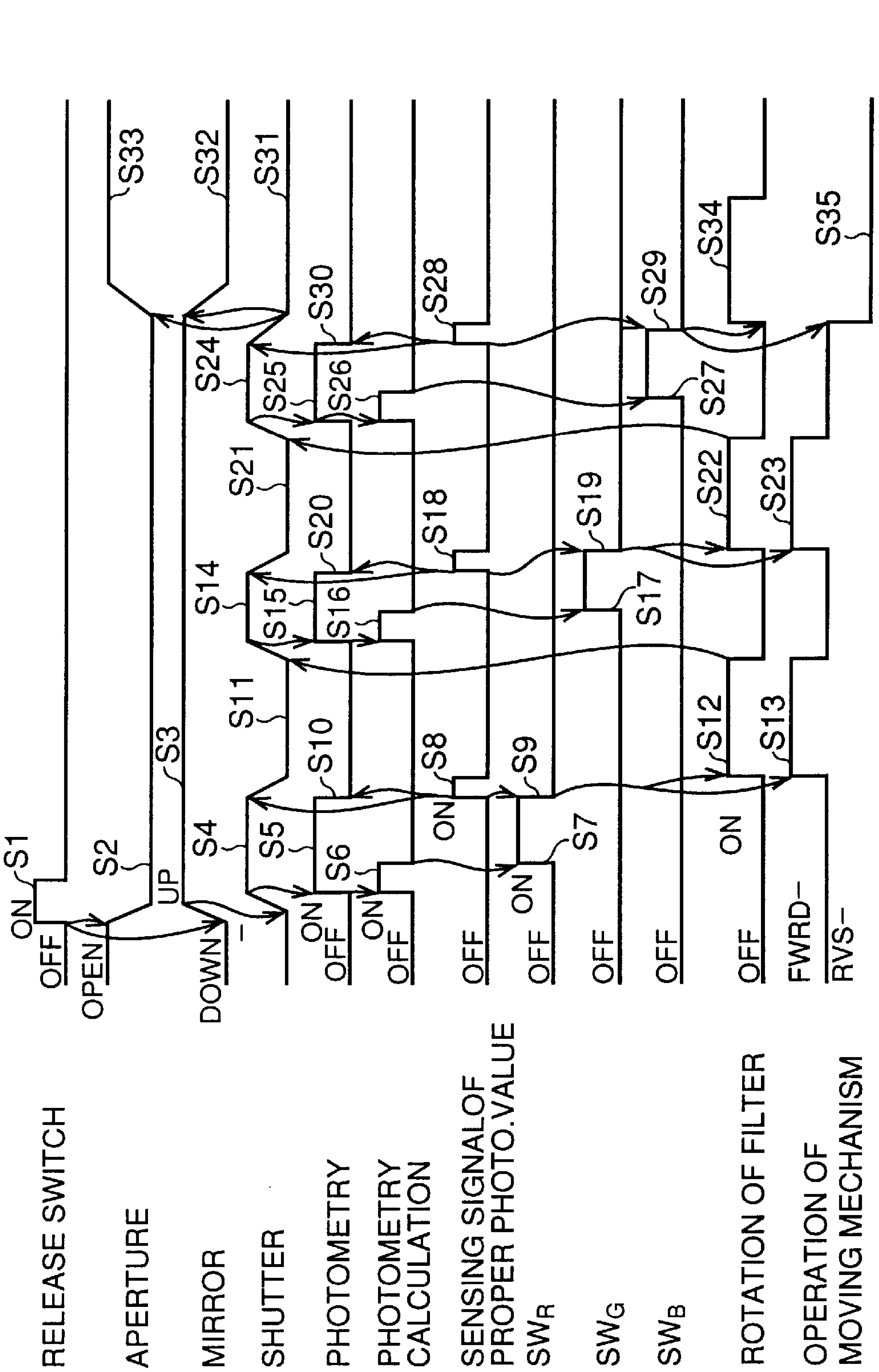

RELEASE SWITCH
APERTURE
MIRROR
SHUTTER
PHOTOMETRY
PHOTOMETRY CALCULATION
SENSING SIGNAL OF PROPER PHOTO.VALUE
SWR
SWG
SWB
ROTATION OF FILTER
OPERATION OF MOVING MECHANISM
ON
OFF
OPEN
UP
DOWN
FWRD
RVS
S1
S2
S3
S4
S5
S6
S7
S8
S9
S10
S11
S12
S13
S14
S15
S16
S17
S18
S19
S20
S21
S22
S23
S24
S25
S26
S27
S28
S29
S30
S31
S32
S33
S34
S35

FIG. 8A

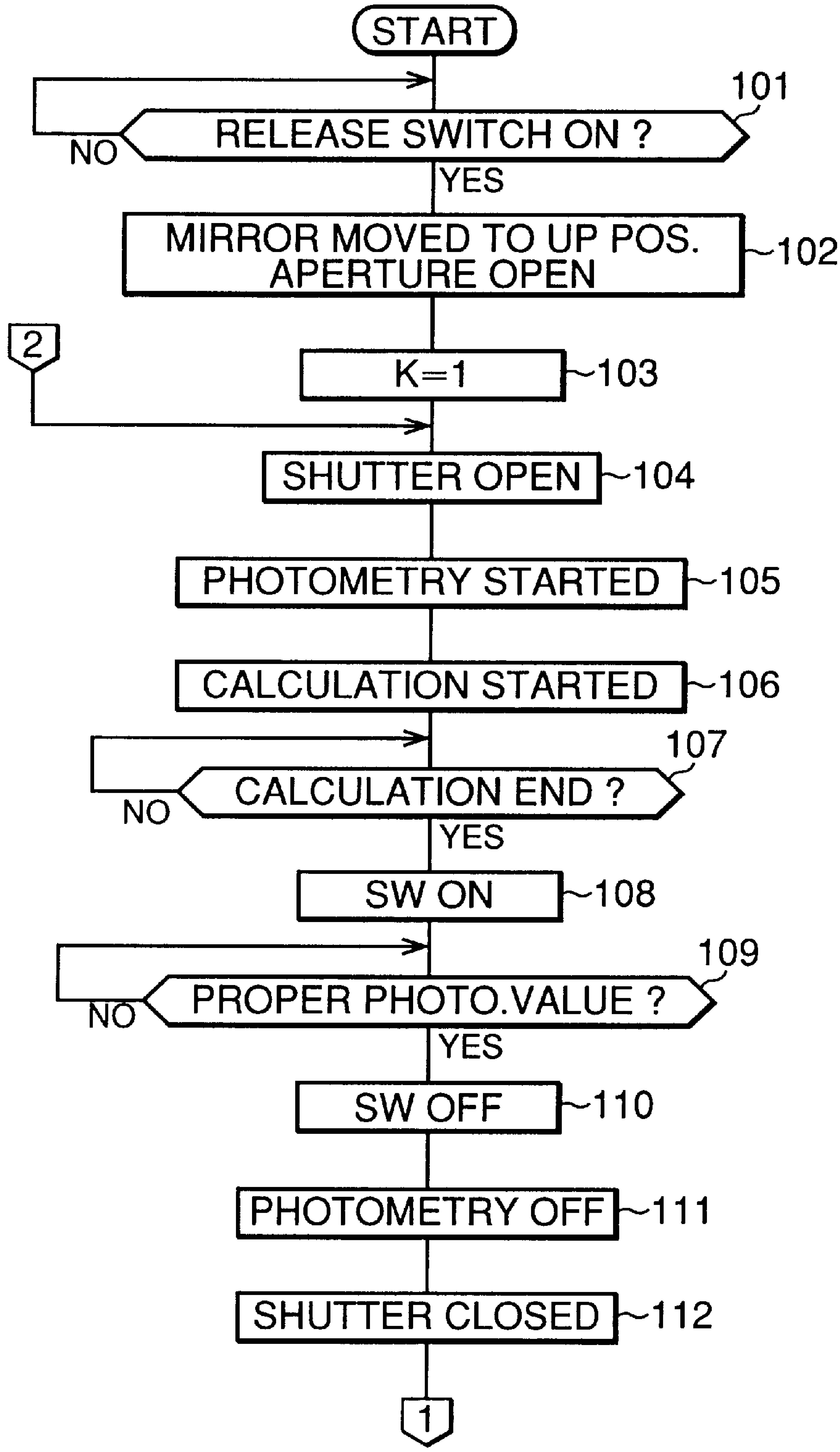

START
RELEASE SWITCH ON ?
101
NO
YES
MIRROR MOVED TO UP POS.
APERTURE OPEN
102
2
K=1
103
SHUTTER OPEN
104
PHOTOMETRY STARTED
105
CALCULATION STARTED
106
107
CALCULATION END ?
NO
YES
SW ON
108
109
PROPER PHOTO.VALUE ?
NO
YES
SW OFF
110
PHOTOMETRY OFF
111
SHUTTER CLOSED
112
1

FIG.8B

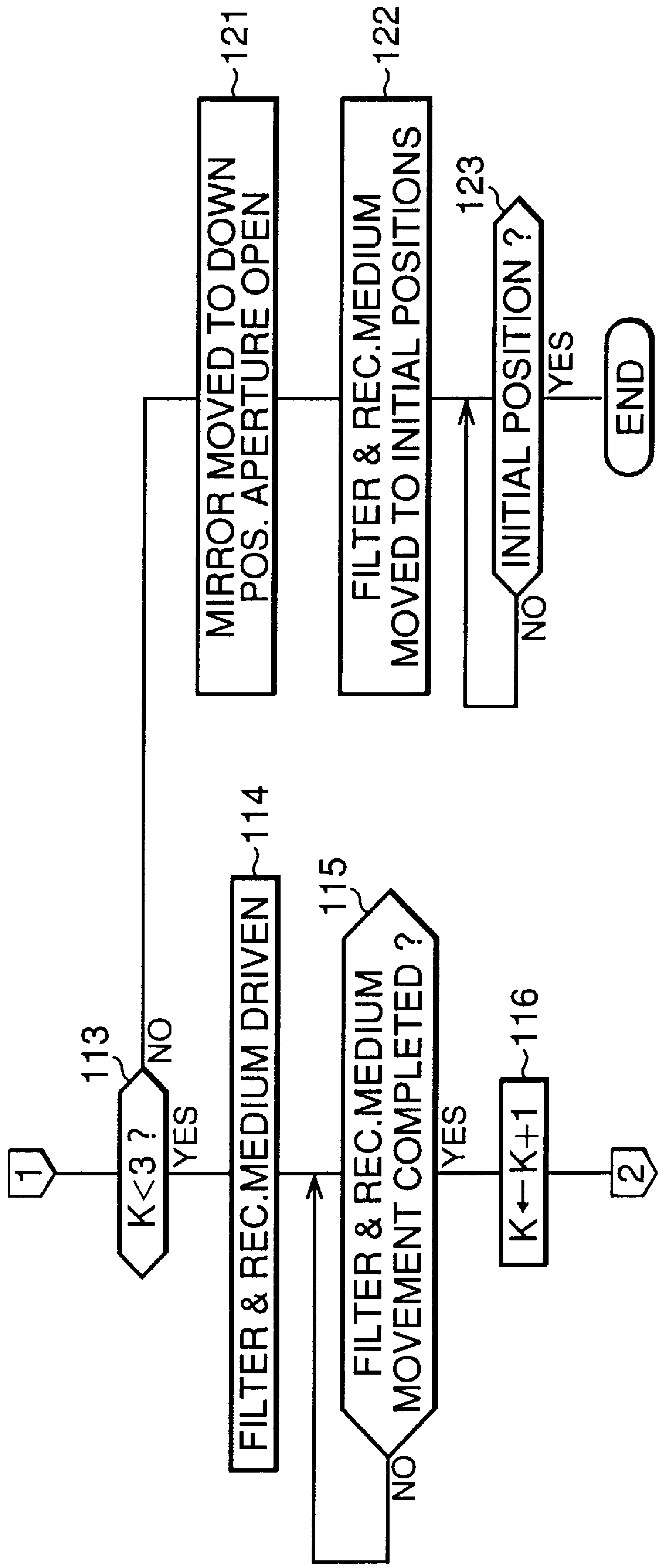

1
K<3 ?
113
YES
NO
FILTER & REC.MEDIUM DRIVEN
114
FILTER & REC.MEDIUM MOVEMENT COMPLETED ?
115
YES
NO
K←K+1
116
2
MIRROR MOVED TO DOWN POS. APERTURE OPEN
121
FILTER & REC.MEDIUM MOVED TO INITIAL POSITIONS
122
INITIAL POSITION ?
123
YES
NO
END

FIG.9

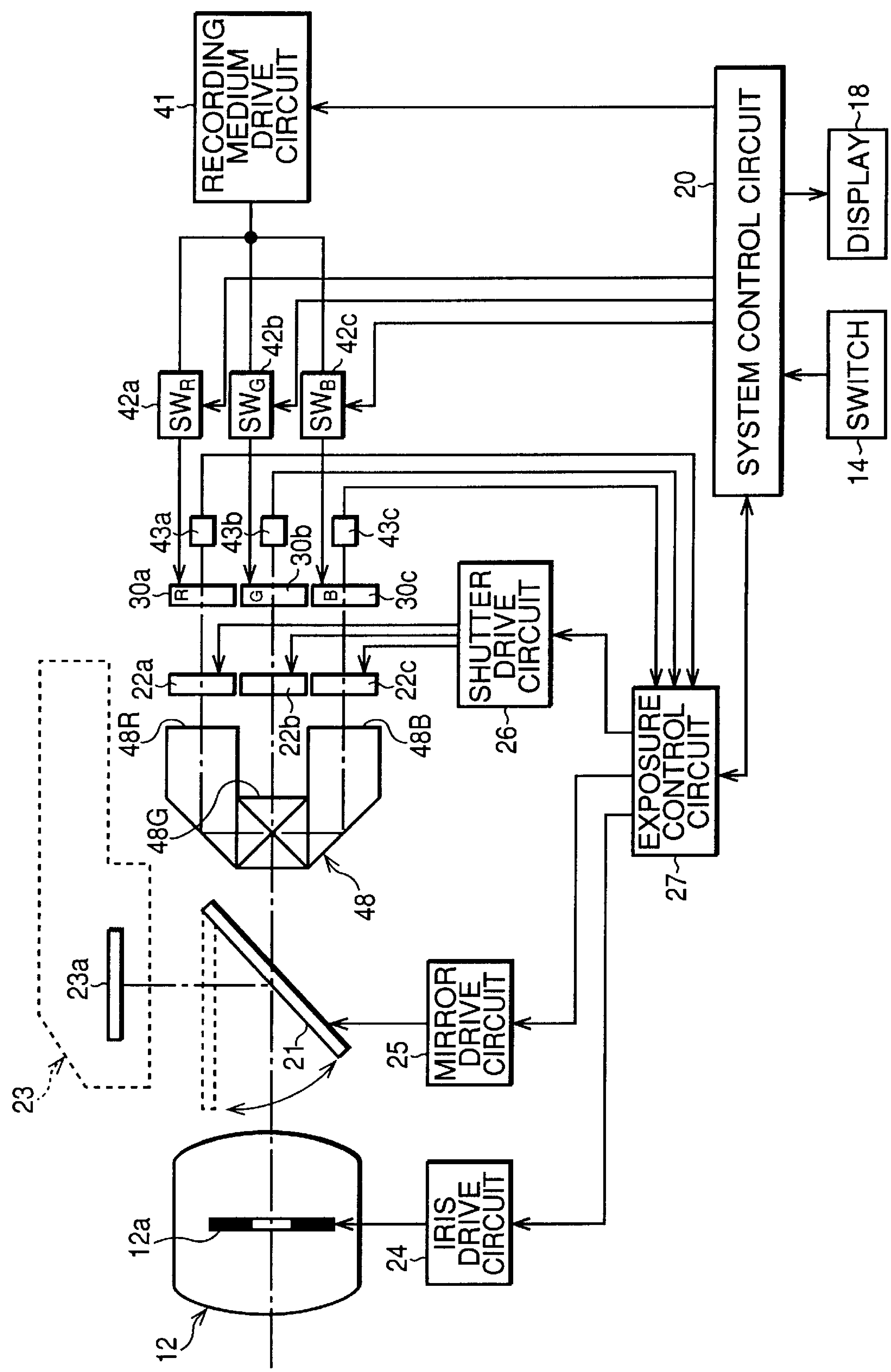
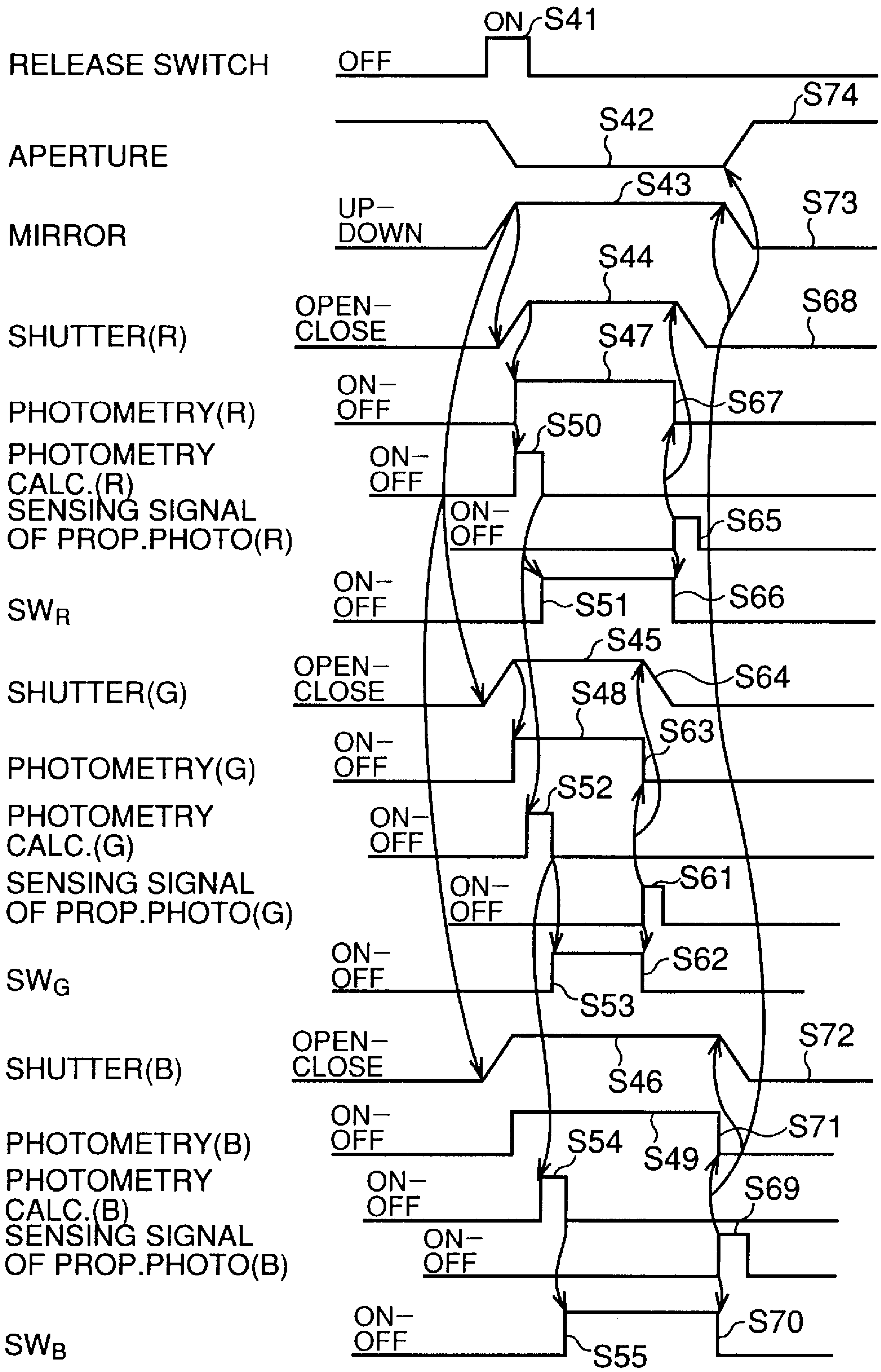

RECORDING MEDIUM DRIVE CIRCUIT
41
SYSTEM CONTROL CIRCUIT
20
DISPLAY
18
SWITCH
14
SWR
SWG
SWB
42a
42b
42c
43a
43b
43c
30a
30b
30c
R
G
B
22a
22b
22c
SHUTTER DRIVE CIRCUIT
26
EXPOSURE CONTROL CIRCUIT
27
48R
48G
48B
48
23
23a
21
MIRROR DRIVE CIRCUIT
25
IRIS DRIVE CIRCUIT
24
12a
12

FIG.10



RELEASE SWITCH
ON
OFF
S41
APERTURE
S42
S74
MIRROR
UP–
DOWN
S43
S73
SHUTTER(R)
OPEN–
CLOSE
S44
S68
PHOTOMETRY(R)
ON–
OFF
S47
S67
PHOTOMETRY CALC.(R)
ON–
OFF
S50
SENSING SIGNAL OF PROP.PHOTO(R)
ON–
OFF
S65
SWR
ON–
OFF
S51
S66
SHUTTER(G)
OPEN–
CLOSE
S45
S64
PHOTOMETRY(G)
ON–
OFF
S48
S63
PHOTOMETRY CALC.(G)
ON–
OFF
S52
SENSING SIGNAL OF PROP.PHOTO(G)
ON–
OFF
S61
SWG
ON–
OFF
S62
S53
SHUTTER(B)
OPEN–
CLOSE
S72
S46
PHOTOMETRY(B)
ON–
OFF
S71
S54
S49
PHOTOMETRY CALC.(B)
ON–
OFF
S69
SENSING SIGNAL OF PROP.PHOTO(B)
ON–
OFF
SWB
ON–
OFF
S70
S55

FIG.11A

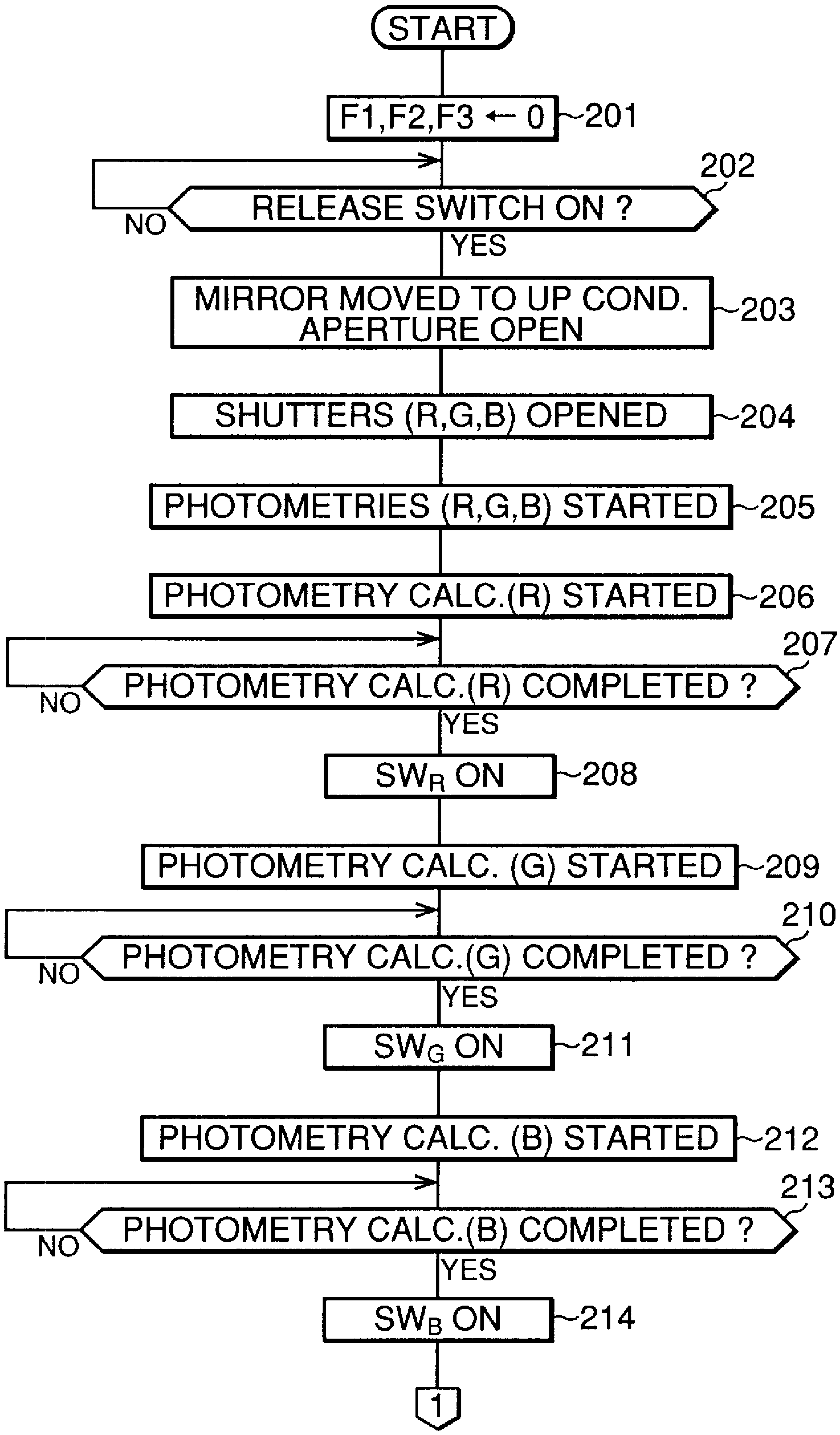
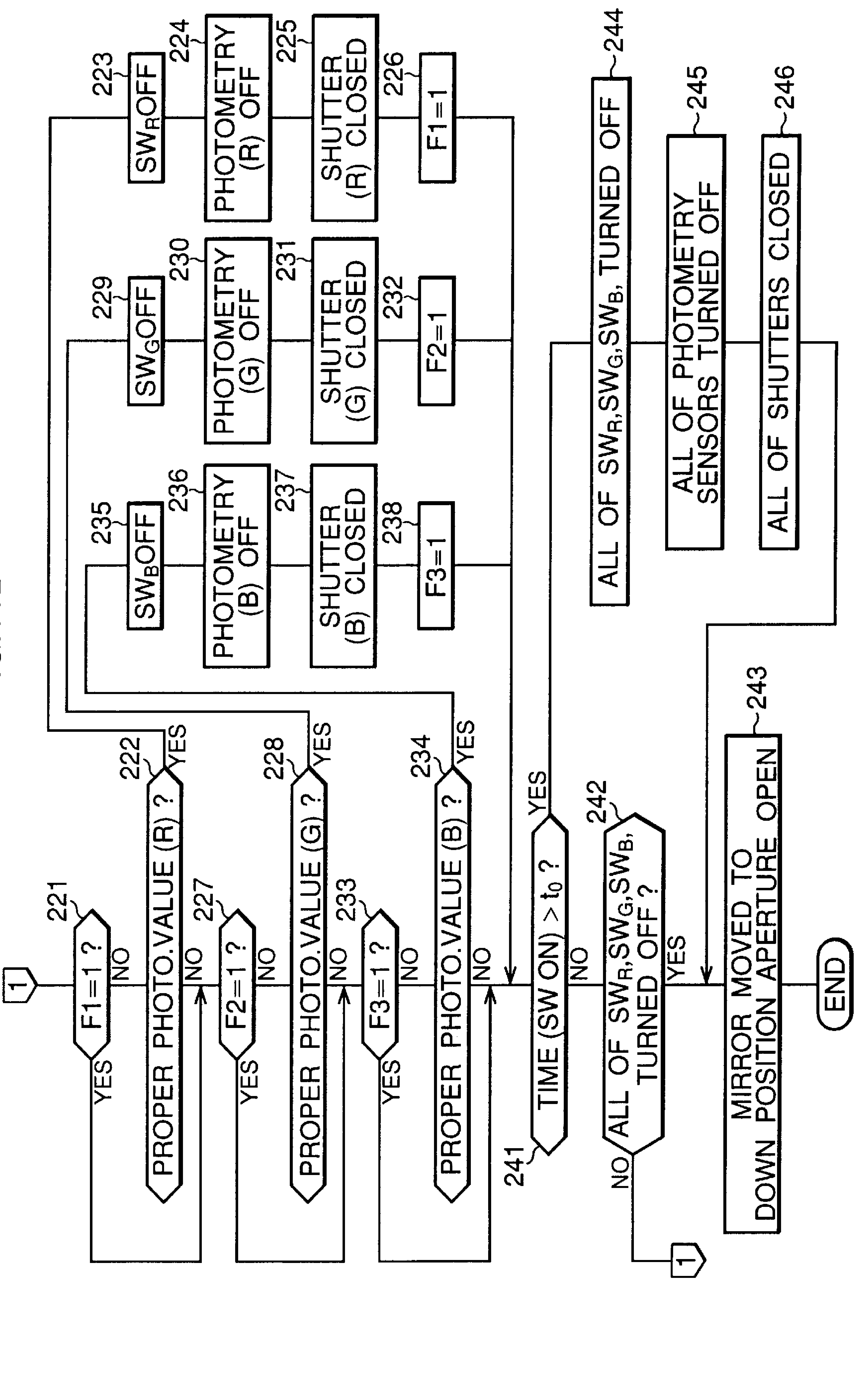

START
F1,F2,F3 ← 0
201
RELEASE SWITCH ON ?
202
NO
YES
MIRROR MOVED TO UP COND.
APERTURE OPEN
203
SHUTTERS (R,G,B) OPENED
204
PHOTOMETRIES (R,G,B) STARTED
205
PHOTOMETRY CALC.(R) STARTED
206
PHOTOMETRY CALC.(R) COMPLETED ?
207
NO
YES
SWR ON
208
PHOTOMETRY CALC. (G) STARTED
209
PHOTOMETRY CALC.(G) COMPLETED ?
210
NO
YES
SWG ON
211
PHOTOMETRY CALC. (B) STARTED
212
PHOTOMETRY CALC.(B) COMPLETED ?
213
NO
YES
SWB ON
214
1

FIG.11B



1
221 F1=1 ?
YES
NO
222 PROPER PHOTO.VALUE (R) ?
YES
NO
223 SW_R OFF
224 PHOTOMETRY (R) OFF
225 SHUTTER (R) CLOSED
226 F1=1
227 F2=1 ?
YES
NO
228 PROPER PHOTO.VALUE (G) ?
YES
NO
229 SW_G OFF
230 PHOTOMETRY (G) OFF
231 SHUTTER (G) CLOSED
232 F2=1
233 F3=1 ?
YES
NO
234 PROPER PHOTO.VALUE (B) ?
YES
NO
235 SW_B OFF
236 PHOTOMETRY (B) OFF
237 SHUTTER (B) CLOSED
238 F3=1
241 TIME (SW ON) > t0 ?
YES
NO
244 ALL OF SW_R,SW_G,SW_B, TURNED OFF
245 ALL OF PHOTOMETRY SENSORS TURNED OFF
246 ALL OF SHUTTERS CLOSED
242 ALL OF SW_R,SW_G,SW_B, TURNED OFF ?
YES
NO
1
243 MIRROR MOVED TO DOWN POSITION APERTURE OPEN
END

# WHITE BALANCE ADJUSTING DEVICE

## BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a camera using a recording medium in which an object image obtained through a photographing optical system is electronically developed, and more particularly, to a device for adjusting a white balance in a developing operation of the recording medium.

2. Description of the Related Art

Conventionally, as disclosed in Japanese Unexamined Patent Publication No. 5-2280 and U.S. Pat. No. 5,424,156, there is known a photographic material which is directly electronically developed so that the developed visible image can be immediately obtained. Such a recording medium will be referred to as an electro-developing recording material herein, and an electronic still camera using the electro-developing recording material is referred to as an electro-developing type camera.

If the electro-developing type camera is designed so as to take a color image, a color separation prism, for example, may be disposed in front of the electro-developing recording medium. The intensity of light of each of the color components, however, is not necessarily the same due to the characteristics of the color separation prism and the illuminating light irradiated onto the object to be photographed. Therefore, it is necessary, for example, to perform a white balance adjustment so that the intensity of light of each color component has the same value when reading the image from the electro-developing recording medium. A signal processing circuit for the white balance adjustment needs to be provided, in such a device, thus causing the electro-developing type camera to have a complex structure.

## SUMMARY OF THE INVENTION

Therefore, an object of the present invention is to provide a white balance adjusting device such that an image taken by the electro-developing type camera has proper or natural colors.

According to the present invention, there is provided a white balance adjusting device mounted in an electro-developing type camera, in which an object image obtained through a photographing optical system is formed on, and electronically developed by, an electro-developing recording medium, the white balance adjusting device comprising a color separation optical system, an output processor, and a control processor.

The color separation optical system forms a plurality of predetermined color images corresponding to the object image. The output processor outputs a control signal in accordance with a transparency of the electro-developing recording medium when each of the predetermined color images is formed on the electro-developing recording medium. The control processor controls the developing operation in the electro-developing recording medium in accordance with the control signal, so that a white balance adjustment for the plurality of predetermined color images developed by the electro-developing recording medium is performed.

Further, according to the present invention, there is provided a white balance adjusting device mounted in an electro-developing type camera, in which an object image obtained through a photographing optical system is formed on, and electronically developed by, an electro-developing recording medium, the white balance adjusting device comprising a color separation optical system and a color component sensing processor.



The color separation optical system forms a plurality of predetermined color images corresponding to the object image. The plurality of predetermined color images are formed on the electro-developing recording medium. The color component sensing processor senses an intensity of light of a predetermined color component, the light of which passes through the electro-developing recording medium and the color separation optical system.

## BRIEF DESCRIPTION OF THE DRAWINGS

The objects and advantages of the present invention will be better understood from the following description, with reference to the accompanying drawings in which:

FIG. **1** is an external view showing an electro-developing type camera to which a first embodiment of the present invention is applied;

FIG. **2** is a block diagram of the electro-developing type camera of the first embodiment;

FIG. **3** is a view showing a positional relationship between a rotational color filter and an electro-developing recording medium;

FIG. **4** is a view showing beams outputted from a photographing optical system and led onto a photometry sensor;

FIG. **5** is a sectional view showing a structure of the electro-developing recording medium;

FIGS. **6**A, **6**B, **6**C and **6**D are graphs for explaining the exposure control in the electro-developing type camera;

FIG. **7** is a timing chart showing a photographing operation of the first embodiment;

FIGS. **8**A and **8**B are flow charts of a program for performing the photographing operation of the first embodiment;

FIG. **9** is a block diagram of the electro-developing type camera to which a second embodiment of the present invention is applied;

FIG. **10** is a timing chart showing a photographing operation of the second embodiment; and

FIGS. **11**A and **11**B are flow charts of a program for performing the photographing operation of the second embodiment.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** is an external view of an electro-developing type camera to which a first embodiment according to the present invention is applied.

When viewing a camera body **11** from the front side, a photographing optical system **12** which includes a photographing lens system, etc. is provided approximately at a center portion of the front surface of the camera body **11**, and an electronic flash **13** is disposed thereon to the right of and above the photographing optical system **12**. A release switch **14** is provided on the side opposite to the electronic flash **13**.

On the upper surface of the camera body **11**, a view finder **15** is provided at a center portion thereof and is extended from the front end to the rear end of the camera body **11**. Switches are provided on the upper surface of the camera body **11**. An output terminal **17** is formed on a lower portion of a side surface of the camera body **11**, so that an image signal obtained by this camera can be outputted to an external recording device.

FIG. **2** is a block diagram of the electro-developing type camera, in which a system control circuit **20** including a microcomputer and a memory **20***d* is mounted to control the electro-developing type camera as a whole.

The photographing optical system **12** has a plurality of lens groups and an aperture **12***a*. An electro-developing recording medium **30** is disposed behind the photographing optical system **12**, and a quick return mirror **21** is placed between the photographing optical system **12** and the electro-developing recording medium **30**. A focusing glass **23***a* included in a view finder optical system **23** is disposed above the quick return mirror **21**. A rotational color filter **45** and a shutter **22** are provided between the quick return mirror **21** and the electro-developing recording medium **30**. The shutter **22** faces the light receiving surface of the electro-developing recording medium **30**. The rotational color filter **45** is disposed in front of the shutter **22**.

FIG. **3** shows a positional relationship between the rotational color filter **45** and the electro-developing recording medium **30**. The rotational color filter **45** is a color separation optical system, and has red (R), green (G), and blue (B) filter elements **45**R, **45**G, and **45**B. The rotational color filter **45** has a disk shape, and the filter elements **45**R, **45**G, and **45**B are defined by three straight lines which are extended radially from the rotational axis **45***a* of the disk to divide it into three equal parts. Namely, each of the filter elements **45**R, **45**G, and **45**B is fan-shaped. The rotational color filter **45** is rotated around the rotational axis **45***a* through a rotational filter drive circuit **46** (see FIG. **2**).

The electro-developing recording medium **30** has three recording areas **30***a*, **30***b*, and **30***c* in which red (R), green (G) and blue (B) images obtained through the rotational color filter **45** are developed, respectively, and is movable in a direction in which these recording areas **30***a*, **30***b*, and **30***c* are aligned. The recording areas **30***a*, **30***b*, and **30***c* are rectangles having the same dimensions, and are constructed in such a manner that one of the recording areas **30***a*, **30***b*, and **30***c* is positioned to face one of the filter elements **45**R, **45**G, and **45**B by the operation of a recording medium moving mechanism **47** (see FIG. **2**). Namely, when the shutter **22** (see FIG. **2**) is opened, one of R, G, and B components is directed to the recording area **30***a*, **30***b*, or **30***c* which is located on the optical axis of the photographing optical system **12**. Note that, in FIG. **3**, the recording area **30***a* faces the filter element **45**R.

With further reference to FIG. **2**, the aperture **12***a*, the quick return mirror **21** and the shutter **22** are driven by an iris drive circuit **24**, a mirror drive circuit **25** and a shutter drive circuit **26**, respectively, all of which are controlled by an exposure control circuit **27**. The exposure control circuit **27** is operated in accordance with a command signal outputted by the system control circuit **20**.

Namely, during exposure, the degree of opening of the aperture **12***a* is adjusted by the iris drive circuit **24** under the control of the exposure control circuit **27** based on a signal outputted by a photometry sensor **28**.

The quick return mirror **21** is normally set to a down position (an inclining position shown by the solid line in the drawing), so that a light beam passing through the photographing optical system **12** is directed to the view-finder optical system **23**, and thus an object to be photographed can be observed by the photographer. When a photographing operation is carried out, the quick return mirror **21** is rotated upward by the mirror drive circuit **25** and set to an up position (a horizontal position shown by the broken line in the drawing), so that the light beam is directed to the electro-developing recording medium **30**.

The shutter **22** is normally closed, but during a photographing operation, the shutter **22** is opened for a predetermined period by the shutter drive circuit **26** under the control of the exposure control circuit **27**. Thus, the light beam passing through the photographing optical system **12** enters a light receiving surface of the electro-developing recording medium **30**, to form a two-dimensional image thereon.

An electric voltage is applied to each of the recording areas **30***a*, **30***b*, and **30***c* of the electro-developing recording medium **30** under the control of the recording medium drive circuit **41**. By exposing the electro-developing recording medium **30** while applying this voltage, R, G, and B images, which are formed by the photographing optical system **12** and the rotational color filter **45**, are developed on the recording areas **30***a*, **30***b*, and **30***c*, as visible images. Note that a period, in which the electric voltage is applied to the electro-developing recording medium **30** is controlled through switches **42***a*, **42***b*, and **42***c*, which are turned ON and OFF through the recording medium drive circuit **41** in accordance with a command signal outputted by the system control circuit **20**.

A release switch **14** is connected to the system control circuit **20**, and a photographing operation is performed by operating the release switch **14**. A display device **18** is connected to the system control circuit **20** to indicate various setting conditions of the electro-developing type camera.

FIG. **4** shows beams outputted from the photographing optical system **12** onto the photometry sensor **43**. As understood from this drawing, a condenser lens **44** is disposed behind the electro-developing recording medium **30**. Namely, the beams are directed to the recording area **30***a* of the electro-developing recording medium **30** from the photographing optical system **12**. The beams pass through the recording area **30***a*, and are concentrated on the light receiving surface of the photometry sensor **43** by the condenser lens **44**. The condenser lens **44** is constructed in such a manner that light, which is outputted from the photographing optical system **12** and corresponds to a whole of the image formed on one recording area, is concentrated on the photometry sensor **43**. In other words, the photometry sensor **43** senses the average value of the intensity of light passing through one recording area.

FIG. **5** shows a structure of the electro-developing recording medium **30**, which is essentially the same as an electro-developing recording medium shown in Japanese Unexamined Patent Publication No. 5-2280.

The electro-developing recording medium **30** has an electrostatic information recording medium **31** and an electric charge storage medium **32**. An electric voltage is applied thereto by an electric power source **33**. The electric power source **33** corresponds to the recording medium drive circuit **41**, so that control of the electric power source **33** (i.e., turning OFF and ON) is an operation in which the recording medium drive circuit **41** applies a recording medium activating signal (a voltage signal) to the electro-developing recording medium **30**.

The electrostatic information recording medium **31** is formed by laminating a base plate **34**, an electrode layer **35**, an inorganic oxide material layer **36**, and a photoconducting layer **37**. The photoconducting layer **37** is formed by laminating an electric charge generating layer **37***a* and an electric charge transferring layer **37***b*. The electric charge storage medium **32** is formed by confining a liquid crystal **40** between a liquid crystal supporting plate **38** and a liquid crystal electrode layer **39**. The electric charge transferring layer **37***b* of the photoconducting layer **37** and the liquid crystal supporting plate **38** of the electric charge storage medium **32** face each other with a small gap therebetween.

When the electric power source **33** is turned ON, an electric voltage is applied between the electrode layer **35** and the liquid crystal electrode layer **39**, i.e., between the electrostatic information recording medium **31** and the electric charge storage medium **32**. When the electrostatic information recording medium **31** is exposed while the electric voltage is applied, an electric charge is generated in the electrostatic information recording medium **31** in accordance with an image formed thereon. Since the intensity of the electric field applied to the liquid crystal display **40** is changed in accordance with the electric charge, the image is indicated on the liquid crystal display **40** as a visible image, and thus, an object image is developed. Namely, the visible image is generated in accordance with the electric charge.

The electric charge storage medium **32** is a liquid crystal display having a memory-type liquid crystal, and thus, the developed visible image is retained therein even if the electric field is removed. The developed visible image of the LCD can be erased by heating it, using a heating device (not shown) to a predetermined temperature. As a result, the same electric charge storage medium **32** can be used repeatedly.

FIGS. **6**A–**6**D shows graphs outlining the exposure control in the electro-developing type camera. In these drawings, at time t=0, the shutter **22** is opened, and an electric voltage is applied to the electro-developing recording medium **30**. Three lines representing the intensities of light entering the electro-developing recording medium **30** are shown, varying from a higher value of $I_1$ to a lower value of $I_3$, with the intensity of light (I=0) corresponding to the dark portion, i.e., a portion into which light does not substantially enter.

The electric voltage V applied to the liquid crystal display **40** of the electro-developing recording medium **30** is increased as the time "t" elapses, and the rate of increase becomes greater as the intensity of light entering the electro-developing recording medium **30** becomes larger.

For example, when the intensity of light is relatively large (i.e., $I_1$), the electric voltage V reaches the threshold value $V_{th}$ at time $t_1$, so that an image having a proper contrast is generated. The electric voltage V reaches the saturation value $V_{st}$ at time $t_2$. Namely, if the exposure and the voltage application are continued after time $t_2$, the portion of the liquid crystal **40** in which the intensity of light is $I_1$ becomes almost transparent, and thus the contrast of the image disappears.

When the intensity of light is $I_2$ (which is less than $I_1$), the electric voltage V reaches the threshold value $V_{th}$ at time $t_3$ (which is later than time $t_1$), and reaches the saturation value $V_{st}$ at time $t_4$ (which is later than time $t_2$).

When the intensity of light is $I_3$ (which is less than $I_2$), the electric voltage V reaches the threshold value $V_{th}$ at time $t_5$ (which is later than time $t_3$), but does not reach the saturation value $V_{st}$ even after time $t_4$.

In case of the dark portion, the electric voltage V reaches the threshold value $V_{th}$ at time $t_0$ (which is later than time $t_3$).

Considering the relationship between the change of the voltage V applied to the liquid crystal display **40** and the transparency T of the electro-developing recording medium **30**, although the transparency T has the minimum value $T_{min}$ when the voltage V is lower than the threshold value $V_{th}$ as shown by the solid line **S1**, the transparency T increases in proportion to the voltage V when the voltage V is higher than the threshold value $V_{th}$. The transparency T reaches the maximum value $T_{max}$ when the voltage V is at the saturation value $V_{st}$.

Regarding the change of the transparency T of the electro-developing recording medium **30** with respect to time, when the intensity of light is $I_1$, the transparency T increases from the minimum value $T_{min}$ at time $t_1$, to the maximum value $T_{max}$ at time $t_2$. When the intensity of light is $I_2$, the transparency T increases from the minimum value $T_{min}$ at time $t_3$, to the maximum value $T_{max}$ at time $t_4$. When the intensity of light is $I_3$, the transparency T increases from the minimum value $T_{min}$ at time $t_5$, and does not reach the maximum value $T_{max}$ however long the period of time that may elapse. For obtaining an image having a proper contrast, the application of voltage to the electro-developing recording medium **30** should be terminated and the shutter **22** should be closed, when the transparency T of the electro-developing recording medium **30** reaches the mean value $(=(T_{max}+T_{min})/2)$ of the maximum value $T_{max}$ and $T_{min}$, for example.

In this embodiment, the intensity of light, which enters the photometry sensor **43** after passing through the electro-developing recording medium **30**, is sensed, so that the operation of terminating the application of voltage and the closing operation of the shutter **22** are controlled. Namely, the photometry sensor **43** outputs a signal corresponding to the intensity of light, and the signal corresponds to the transparency T of each of the recording areas **30***a*, **30***b*, and **30***c*.

When the application of voltage is terminated and the shutter **22** is closed, the intensity of light entering the photometry sensor **43** is:

$$I'=I\cdot(T_{min}+T_{max})/2 \tag{1}$$

This can be transformed into as follows:

$$\begin{aligned} I' &= I\cdot T_{\min}\cdot(1+(T_{\max}/T_{\min}))/2 \\ &= I'(t=0)\cdot(1+(T_{\max}/T_{\min}))/2 \end{aligned} \tag{2}$$

wherein $(1+(T_{max}/T_{min}))/2$ is a coefficient which is a constant determined in accordance with the characteristics of the liquid crystal **40**. I'(t=0) is data sensed by the photometry sensor **43** when the shutter **22** is opened and before the application of voltage is begun.

Thus, in this embodiment, when the intensity of light I' sensed by the photometry sensor **43** reaches the proper value obtained by relationship (2), it is deemed that the transparency of the electro-developing recording medium **30** has become the mean value $(T_{max}+T_{min})/2$ of the maximum value $T_{max}$ and $T_{min}$. At this juncture, the application of power is removed and the shutter **22** is closed. In the example shown in FIGS. **6**A–**6**D, the electric voltage of the electro-developing recording medium **30** is removed and the shutter **22** is closed at time $t_{f1}$ when the intensity of light is $I_1$, at time $t_{f2}$ when the intensity of light is $I_2$, and at time $t_{f3}$ when the intensity of light is $I_3$.

FIG. **7** is a timing chart showing a photographing operation, and FIGS. **8**A and **8**B are flow charts of a program for performing the photographing operation. With reference to these drawings, operations of this embodiment are described below. Note that this program is started when the power supply of the electro-developing type camera is turned ON. When the program is started, the aperture **12***a* is fully opened, the quick return mirror **21** is set at the down position, the shutter **22** is closed, and the rotational color filter **45** is positioned in such a manner that the first recording area **30***a* faces the rear surface of the R-filter element **45**R. Namely, the rotational color filter **45** and the electro-developing recording medium **30** are set at the positions shown in FIG. **3**.

When it is sensed in Step **101** that the release switch **14** has been depressed (reference S1), then in Step **102**, the degree of opening of the aperture **12***a* is changed from the fully open state to a predetermined degree of opening (reference S2) in accordance with an aperture value set by a manual handling of the photographer, and the quick return mirror **21** is changed from the down position to the up position (reference S3). In Step **103**, a counter K is set to 1. The value of the counter K corresponds to the rotational position of the rotational color filter **45**. Namely, when the counter K is 1, 2, or 3, the R-filter element **45**R, the G-filter element **45**G, and the B-filter element **45**B are positioned on the optical axis of the photographing optical system **12**, respectively.

The shutter **22** is opened in Step **104** (reference S4), and a photometry by the photometry sensor **43** is started (reference S5) in Step **105**. In Step **106**, a photometry calculation is started (reference S6), and thus the sensed data of the photometry sensor **43** is multiplied by the coefficient of the liquid crystal **40** (FIG. **5**) according to the relationship formula (2), so that a proper photometry value, which corresponds to the intensity of light sensed by the photometry sensor **43** when a proper exposure is obtained, is calculated.

When it is sensed in Step **107** that the photometry calculation has been completed, the switch **42***a* is turned ON (reference S7) in Step **108**. In Step **109**, it is determined whether the sensed data obtained by the photometry sensor **43** reaches a value corresponding to the proper photometry value obtained in Step **106**, i.e. whether the sensed data satisfies the relationship (2). When the sensed data reaches the proper photometry value (reference S8), the switch **42***a* is turned OFF (reference S9) in Step **110**. Then, in Step **111**, the photometry by the photometry sensor **43** is stopped (reference S10), and in Step **112**, the shutter **22** is closed (reference S11).

Then, it is determined in Step **113** whether the counter K is less than 3. When the counter K is less than 3, i.e. when the recording operations of the image for all of the recording areas **30***a*, **30***b*, and **30***c* have not yet been completed, Step **114** is executed so that the rotational color filter **45** is rotated (reference S12), the motor of the recording medium moving mechanism **47** is rotated in forward direction so that the electro-developing recording medium **30** is advanced or moved upward (reference S13). In Step **115**, it is determined whether the rotation of the rotational filter **45** and the advancement of the electro-developing recording medium **30** are completed. When the rotational color filter **45** is rotated by approximately 120 degrees, so that the G-filter element **45**G is positioned on the optical axis of the photographing optical system **12**, and the second recording area **30***b* of the electro-developing recording medium **30** is positioned on the optical axis of the photographing optical system **12**, the process goes from Step **115** to Step **116**, and thus the counter K is increased by one.

Then, the process returns to Step **104**, and Steps **104** through **112** are again executed. Namely, after the shutter **22** is opened (reference S14), the photometry by the photometry sensor **43** is started (reference S15), and the photometry calculation is started (reference S16) to obtain a proper photometry value. When the photometry calculation is completed, the switch **42***b* is turned ON (reference S17). Then, when the sensed data of the photometry sensor **43** becomes approximately the proper photometry value (reference S18), the switch **42***c* is turned OFF (reference S19), the photometry by the photometry sensor **43** ends (reference S20), and the shutter **22** is closed (reference S21).

Then, since it is determined in Step **113** that the counter K is less than 3, Step **114** is executed so that the rotational color filter **45** is rotated (reference S22), and the electro-developing recording medium **30** is advanced upward (reference S23). When it is confirmed in Step **115** that the rotation of the rotational filter **45** and the advancement of the electro-developing recording medium **30** are completed, i.e., when it is confirmed that the B-filter element **45**B is positioned on the optical axis of the photographing optical system **12**, and the third recording area **30***c* is positioned on the optical axis of the photographing optical system **12**, Step **116** is executed so that the counter K is increased by one.

Then, the process returns to Step **104**, and Steps **104** through **112** are again executed so that the recording operation to the third recording area **30***c* is performed. Note that the numerals included in references S24 through S31 are obtained by adding **10** to the numerals included in references S14 through S21 which show the same operations as those shown by references S24 through S31.

Thus, the R image, G image, and B image are recorded in each of the recording areas **30***a*, **30***b*, and **30***c* of the electro-developing recording medium **30**.

At this point, in Step **113**, since the counter K has reached 3 due to the previous execution of Step **116**, the process branches to Step **121**, in which the quick return mirror **21** is changed from the up position to the down position (reference S32), and the aperture **12***a* is set to the fully open condition (reference S33). In Step **122**, the rotational color filter **45** is rotated (reference S34), and the electro-developing recording medium **30** is moved downward (reference S35). Specifically, the rotational color filter **45** is rotated in the same direction as in the previous operation, and the electro-developing recording medium **30** is moved in the opposite direction to that in the previous operation, so that the rotational color filter **45** and the electro-developing recording medium **30** return to their initial positions, respectively. In Step **123**, it is determined whether the rotation of the rotational filter **45** and the reverse movement of the electro-developing recording medium **30** are completed. The color filter **45** is rotated by approximately 120 degrees so that the R-filter element **45**R is positioned on the optical axis of the photographing optical system **12**, and the first recording area **30***c* of the electro-developing recording medium **30** is positioned on the optical axis of the photographing optical system **12**, and thus the color filter **45** and the electro-developing recording medium **30** return to the initial positions, respectively, and thenceforth this program ends.

As described above, in the first embodiment, the intensity of light of each of the color components entering the recording areas **30***a*, **30***b*, and **30***c* is directly sensed by the photometry sensor **43** disposed behind the electro-developing recording medium **30**, and using the result of sensing, the developing operations of the recording areas **30***a*, **30***b*, and **30***c* are controlled independently each other. Therefore, according to the first embodiment, the white balance adjustment can be carried out precisely.

FIG. **9** is a block diagram of the electro-developing type camera to which a second embodiment of the present invention is applied. Note that the external view of the electro-developing type camera of the second embodiment is the same as that shown in FIG. **1**.

In the second embodiment, a color separation prism **48**, which color-separates an object image into R, G, and B components, is provided instead of the rotational color filter **45**, whose construction is different from the first embodiment. The color separation prism **48** is provided with first, second, and third emergent planes **48**R, **48**G, and **48**B which correspond to R, G, and B images. Shutters **22***a*, **22***b*, and **22***c* are positioned behind the first, second, and third emergent planes **48**R, **48**G, and **48**B, respectively. The first, second, and third recording areas **30***a*, **30***b*, and **30***c* of the electro-developing recording medium, are provided behind the shutter **22***a*, **22***b*, and **22***c*, respectively. Note that, for forming a focused image on each of the light receiving surfaces of the recording areas **30***a*, **30***b*, and **30***c*, a proper optical system can be disposed behind each of the emergent planes **48**R, **48**G, and **48**B.

Photometry sensors **43***a*, **43**b, and **43***c* are provided behind the recording areas **30***a*, **30***b*, and **30***c*, and each of the photometry sensors **43***a*, **43**b, and **43***c* senses the intensity of substantially all of the light passing through each of the recording media.

Opening and closing operations of the shutters **22***a*, **22***b*, and **22***c* are controlled by the shutter drive circuit **26**, during the application of voltage to the recording areas **30***a*, **30***b*, and **30***c* of the electro-developing recording medium **30** is controlled through switches **42***a*, **42***b*, and **42***c*. The other constructions are the same as those of the first embodiment.

FIG. **10** is a timing chart showing a photographing operation of the second embodiment, and FIGS. **11**A and **11**B are flow charts of a program for performing the photographing operation. With reference to these drawings, operations of the second embodiment are described below. Note that, similar to the first embodiment, this program is started when the power supply of the electro-developing type camera is turned ON. Further, when the program is started, the aperture **12***a* is fully opened, the quick return mirror **21** is set at the down position, and all of the shutters **22***a*, **22***b*, and **22***c* are closed.

In step **201**, flags F1, F2, and F3 are reset to 0, respectively. When it is sensed in Step **202** that the release switch **14** is turned ON (reference S**41**), the degree of opening of the aperture **12***a* is changed from the fully open state to a predetermined degree of opening (reference S**42**) in accordance with an aperture value set by a manual handling of the photographer. Simultaneously, the quick return mirror **21** is changed from the down position to the up position (reference S**43**).

In Step **204**, the shutters **22***a*, **22***b*, and **22***c* are opened (references S**44**, S**45**, S**46**). In Step **205**, photometry measurements performed by the photometry sensors **43***a*, **43***b*, and **43***c* are started (references S**47**, S**48**, S**49**).

In Step **206**, a photometry calculation for an R image is started (reference S**50**), and thus, the intensity of light, which is sensed by the photometry sensor **43***a* when a proper exposure is obtained, is calculated according to the relationship (2). When it is confirmed in Step **207** that the photometry calculation has been completed, the switch **42***a* is turned ON (reference S**51**) in Step **208**. Similarly, in Step **209**, a photometry calculation for a G image is started (reference S**52**), and a data sensed by the photometry sensor **43***b* during a proper exposure is calculated. When it is confirmed in Step **210** that the photometry calculation has been completed, the switch **42***b* is turned ON (reference S**53**) in Step **211**. In Step **212**, a photometry calculation for a B image is started (reference S**54**), and thus, a data sensed by the photometry sensor **43***c* during a proper exposure is calculated. When it is confirmed in Step **213** that the photometry calculation has been completed, the switch **42***c* is turned ON (reference S**55**) in Step **214**.

In Step **221**, it is determined whether the flag F1 has a value of 1. This flag F1 is set to 1 in Step **226**, when a recording operation (i.e., a developing operation) by the recording area **30***a* corresponding to the R image is completed. When Step **221** is executed for the first time, the flag F1 has a value of 0. In this case, the process branches to Step **222** in where it is determined whether the data sensed by the photometry sensor **43***a* has reached the proper photometry value obtained in Step **206**. In the example shown in FIG. **10**, the data sensed by the photometry sensor **43***b*, corresponding to the G image, reaches the proper photometry value before that of the R and B images. Therefore, in Step **222**, it is determined that the sensed data of the photometry sensor **43***a* has not reached the proper photometry value. Namely, the process branches to Step **227**, and it is determined whether the flag F2 has a value of 1. When Step **228** is executed for the first time, the flag F2 has a value of 0. In this case, it is determined in Step **228** whether the data sensed by the photometry sensor **43***b* has reached the proper photometry value obtained in Step **209**, i.e. whether the sensed data satisfies relationship (2).

As an explanation, it is assumed that the data sensed by the photometry sensor **43***b* approximates the proper photometry value (reference S**61**). Namely, the process branches to Step **229**, in which the switch **42***b* is turned OFF (reference S**62**). Then, the photometry by the photometry sensor **43***b* is stopped (reference S**63**) in Step **230**, the shutter **22***b* is closed (reference S**64**) in Step **231**, and the flag F2 is set to 1 in Step **232**.

In Step **241**, it is determined whether or not a time span, during which either of the switches **42***a*, **42***b*, or **42***c* were turned ON, was over the maximum time period $t_0$. That is, the maximum time period $t_0$ is the length of time for which an electric voltage applied to a dark portion of the liquid crystal reaches the threshold value $V_{th}$, as described above with reference to FIG. **6**A. Since an over-exposure would occur even in the dark portion after the maximum time $t_0$, the photographing operation should be stopped. Conversely, when the maximum time $t_0$ has not elapsed, Step **242** is executed in which it is determined whether all of the switches **42***a*, **42***b*, and **42***c* have been turned OFF. Note, when Step **242** is executed for the first time, since all of the switches **42***a*, **42***b*, and **42***c* have not been turned OFF, the process returns to Step **221**.

In Step **221**, as described above, it is determined whether the flag F1 has a value of 1. In the example shown in FIG. **10**, immediately after the recording operation, in which the G image is recorded in the recording area **30***b* is completed, the recording operation in which the R image is recorded in the recording area **30***a*, needs to be completed. Therefore, the process goes to Step **222** in which it is determined whether the data sensed by the photometry sensor **43***a* has reached the proper photometry value. When the sensed data has reached the proper photometry value (reference S**65**), Step **223** is executed in which the switch **42***a* is turned OFF (reference S**66**). Also, Step **224** is executed in which the photometry, by the photometry sensor **43***a*, is stopped (reference S**67**). Then, in Step **225**, the shutter **22***a* is closed (reference S**68**), and in Step **226**, the flag F1 is set to 1. Then, Steps **241** and **242** are executed in that order, after which the process returns to Step **221**.

In the example shown in FIG. **10**, the recording operations of the R and G images onto the recording areas **30***a* and **30***b* have already been completed, and the flags F1 and F2 have been set to 1, respectively. Therefore, after Steps **221** and **227** are executed in that order, it is determined in Step **233** whether the flag F3 has a value of 1. Immediately after the recording operation of the R image onto the recording area **30***a* is completed, the recording operation of the B image onto the recording area **30***c* needs to be completed. Therefore, the flag F3 has a value of 3. As a result, the process branches to Step **234**, in which it is determined whether or not the data sensed by the photometry sensor **43***c* approximates the proper photometry value. When the sensed data by the photometry sensor **43***c* has approximately reached the proper photometry value (reference **S69**), Step **235** is executed in which the switch **42***c* is turned OFF (reference **S70**). Also, Step **236** is executed in which the photometry, by the photometry sensor **43***c*, is stopped (reference **S71**). Then, in Step **237**, the shutter **22***c* is closed (reference **S72**), and in Step **238**, the flag F3 is set to 1.

When it is determined in Step **241** that the maximum time $t_0$ has not elapsed, Step **242** is executed in which it is determined whether all of the switches **42***a*, **42***b*, and **42***c* are turned OFF. In the example shown in FIG. **10**, when the recording operation of the B image onto the recording area **30***c* has been completed, all of the switches **42***a*, **42***b*, and **42***c* are turned OFF. Therefore, the process jumps from Step **242** to Step **243**, so that the quick return mirror **21** is changed from the up position to the down position (reference **S73**), and the aperture **12***a* is set to the fully opened condition (reference **S74**). Thus, the program ends.

On the other hand, when it is determined in Step **241** that the maximum time $t_0$ has elapsed, Steps **244** through **246** are executed. Namely, in Step **244**, all of the switches **242***a*, **242***b*, and **242***c* are turned OFF, and in Step **245**, all of the photometry sensors **43***a*, **43***b*, and **43***c* are turned OFF. Then, in Step **246**, all of the shutters **22***a*, **22***b*, and **22***c* are closed, and the program ends.

According to the second embodiment, similar to the first embodiment, the white balance adjustment can be carried out precisely for the image of each of the color components recorded in the recording areas **30***a*, **30***b*, and **30***c*. Further, according to the second embodiment, and in contrast to the first embodiment, the mechanical structure is simple, since the color separation optical system (i.e., color separation prism **48**) does not need to be rotated.

Note that the electro-developing recording medium **30** is not restricted to the construction described above, but can be any medium in which an image is developed electronically.

Although the embodiments of the present invention have been described herein with reference to the accompanying drawings, obviously many modifications and changes may be made by those skilled in this art without departing from the scope of the invention.

The present disclosure relates to subject matter contained in Japanese Patent Application No. 8-28496, (filed on Jan. 23, 1996) which is expressly incorporated herein, by reference, in its entirety.

We claim:

**1**. A white balance adjusting device mounted in an electro-developing type camera, in which an object image obtained through a photographing optical system is formed on, and electronically developed by, an electro-developing recording medium, which comprises a plurality of recording areas, said white balance adjusting device comprising:

a color separation optical system forming a plurality of predetermined color images corresponding to the object image;

an output processor which receives light corresponding to an entire image formed on one of said plurality of recording areas of said electro-developing receiving medium and outputs a control signal in accordance with an intensity of the received light which varies in accordance with a transparency of said recording area of said electro-developing recording medium when each of said predetermined color images is formed on said electro-developing recording medium; and

a control processor which controls a developing operation of said electro-developing recording medium in accordance with said control signal, so that a white balance adjustment for said plurality of predetermined color images developed by said electro-developing recording medium is performed.

**2**. A white balance adjusting device according to claim **1**, each of said plurality of predetermined color images being developed in one of said plurality of recording areas.

**3**. A white balance adjusting device according to claim **2**, wherein said control processor independently controls the developing operation of each of said plurality of recording areas, in accordance with said control signal.

**4**. A white balance adjusting device according to claim **1**, wherein said control processor has a photometry sensor which senses an intensity of light passing through each of said plurality of recording areas.

**5**. A white balance adjusting device according to claim **4**, wherein said photometry sensor senses the intensity of substantially all of the light passing through each of said plurality of recording areas.

**6**. A white balance adjusting device according to claim **1**, further comprising a shutter facing said electro-developing recording medium, said shutter opening and closing in accordance with said control signal.

**7**. A white balance adjusting device according to claim **6**, wherein said shutter closes when said transparency becomes a value which is between a maximum value and a minimum value of said transparency.

**8**. A white balance adjusting device according to claim **1**, further comprising an electric power controlling processor which applies an electric voltage to said electro-developing recording medium, said electric power controlling processor controlling said electric voltage in accordance with said control signal.

**9**. A white balance adjusting device according to claim **8**, wherein said electric power controlling processor stops the application of the electric voltage when said transparency has a value which is between a maximum value and a minimum value of said transparency.

**10**. A white balance adjusting device according to claim **1**, wherein said plurality of predetermined color images are red, green, and blue images.

**11**. A white balance adjusting device according to claim **1**, wherein said color separation optical system is provided between said photographing optical system and said electro-developing recording medium, said color separation optical system comprising a rotational color filter having red, green, and blue filter elements.

**12**. A white balance adjusting device according to claim **11**, further comprising a moving mechanism which moves said electro-developing recording medium in such a manner that one of said recording areas faces one of said red, green, and blue filter elements.

**13**. A white balance adjusting device according to claim **1**, wherein said color separation optical system comprises a color separation prism which separates the object image into red, green, and blue components.

**14**. A white balance adjusting device according to claim **1**, wherein said electro-developing recording medium comprises an electrostatic information recording medium generating an electric charge in accordance with an image formed thereon, and an electric charge storage medium which generates a visible image in accordance with said electric charge and which can retain said visible image.

**15**. A white balance adjusting device according to claim **1**, wherein said electric charge storage medium is a liquid crystal display having a memory-type liquid crystal.

**16**. A white balance adjusting device mounted in an electro-developing type camera, in which an object image obtained through a photographing optical system is formed on and electronically developed by an electro-developing recording medium which comprises a plurality of recording areas, said white balance adjusting device comprising:

a color separation optical system that forms a plurality of predetermined color images corresponding to the object image, said plurality of predetermined color images being formed on said electro-developing recording medium; and

a color component sensing processor that receives light corresponding to an entire image formed on one of said plurality of recording areas and senses an intensity of light of a predetermined color component, said light passing through said electro-developing recording medium and said color separation optical system, said color component sensing processor outputs a signal related to the intensity of sensed light which varies in accordance with a transparency of said one of said recording areas.

**17**. A white balance adjusting device according to claim **16**, wherein said color component sensing processor senses the intensity of substantially all of the light passing through each of said plurality of recording areas.

**18**. A white balance adjusting device mounted in an electro-developing type camera, in which an object image obtained through a photographing optical system is formed on, and electronically developed by, an electro-developing recording medium which comprises a plurality of recording areas, said white balance adjusting device comprising:

a color separation optical system that forms a plurality of predetermined color images corresponding to the object image;

an outputting system that receives light corresponding to an entire image formed on one of said plurality of recording areas of said electro-developing recording medium and outputs a control signal in accordance with a transparency of said one of said plurality of recording areas of said electro-developing recording medium when each of said predetermined color images is formed on said electro-developing recording medium; and

a system that controls the developing operation in said electro-developing recording medium in accordance with said control signal, so that a white balance adjustment for said plurality of predetermined color images developed by said electro-developing recording medium is performed.

**19**. A white balance adjusting device according to claim **18**, wherein said control system has a photometry sensor which senses an intensity of light passing through each of said plurality of recording areas.

**20**. A white balance adjusting device according to claim **19**, wherein said photometry sensor senses the intensity of substantially all of the light passing through each of said plurality of recording areas.

* * * * *